

- 14 -

CLAIMS

1. Exoskeleton interface apparatus for detecting the posture of a limb of an user and/or for reflecting controlled forces on the user, whose characteristic is  
5 that it comprises:

- at least an element of interaction with an operator;
- a plurality of rigid links pivotally connected in series, between said element of interaction and a rigid fixed link, by means of rotational joints whose  
10 rotational axes coincide substantially in operative conditions with the physiological axes of at least one limb of the user;
- means arranged in said rigid fixed link for generating a motive or braking force;
- 15 - means for transmitting said force to said rotational joints;
- means for measuring the angular position of said rotational joints.

2. Exoskeleton interface apparatus according to claim 1,  
20 wherein said rigid links comprise:

- said rigid fixed link, or base frame, connected to a fixed plane and operatively connected to a second rigid link by a first rotational joint having an axis of rotation;
- 25 - a third rigid link operatively connected to said second rigid link by means of a second rotational joint having axis of rotation orthogonal to the axis of rotation of the first rotational joint;

- 15 -

- a fourth rigid link operatively connected to said third rigid link by means of a third rotational joint with axis of rotation orthogonal to the axis of the second rotational joint;
  - 5    - a fifth rigid link associated to said element of interaction operatively connected to said fourth rigid link by means of a fourth rotational joint.
3. Exoskeleton interface apparatus according to claim 2, wherein, when the exoskeleton interface apparatus is used for monitoring the motion of the shoulder, of the arm and of the wrist of an operator, the axes of the first, of the second and of the third rotational joint are incident in a point at the physiological centre of the shoulder, whereas the axis of the fourth rotational joint coincides with the physiological axis of the elbow.
- 10    4. Exoskeleton interface apparatus according to claim 1, wherein said element of interaction is connected to the fifth rigid link by means of a fifth rotational joint, for example a ring bearing, for measuring the rotation of the wrist with respect to the forearm.
- 15    5. Exoskeleton interface apparatus according to claim 1, wherein said applied force brakes the free movement of said rigid link due to the movement of a limb of the user.
- 20    6. Exoskeleton interface apparatus according to claim 1, wherein said means for generating said force are motors, in particular "torque motors", with a high torque/mass ratio.
- 25

- 16 -

7. Exoskeleton interface apparatus according to claim 1,  
wherein each rotational joint is brought independently  
into rotation about the respective axis, by one of  
said means for generating a force through said means  
5 for transmitting said force.
8. Exoskeleton interface apparatus according to claim 1,  
wherein said means for transmitting said force  
comprise at least one tendon, whereby each means for  
generating said force is operatively connected to a  
10 rotational joint by said at least one tendon.
9. Exoskeleton interface apparatus according to claim 1,  
in which the rotational axes of the rotational joints  
lay in different planes, whereby a plurality is  
provided of means for orienting said means for  
15 transmitting said force.
10. Exoskeleton interface apparatus according to claim 1,  
wherein said means for transmitting are tensioning  
tendons, said means for orienting being idle pulleys  
spatially arranged along said rigid links.
- 20 11. Exoskeleton interface apparatus according to claim 2,  
wherein at least one joint of the exoskeleton  
structure has open geometry, in particular said third  
rotational joint has open geometry.
12. Exoskeleton interface apparatus according to claim 2,  
25 wherein on the axis of the first, third and fourth  
rotational joint an integrated epicyclic reduction  
gear is mounted for reducing the masses of the rigid  
links at the same conditions of stiffness and applied  
force.

- 17 -

13. Exoskeleton interface apparatus according to claim 1,  
wherein said means for measuring the angular position  
of said rotational joints are mounted directly on the  
axis of said means for generating said force, in  
5 particular said means for measuring being high  
resolution incremental encoders.